

Reciprocating  
Engines on  
Digester Gas

2006

# Beginnings

1980's

- Mason-Dixon Farms
- Harlan Keener (Rocky Knoll)
- Oregon Dairies
- Green Meadow Farms

# Developments

1990's



Sochi, Russia

- Co-Generation experience
- Remote Installations

- Switchgear Demand creates GEN-TEC LLC
- Interties with the Grid valuable experience

Los Angeles, CA

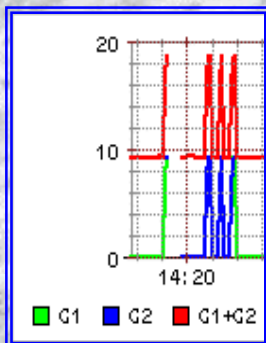
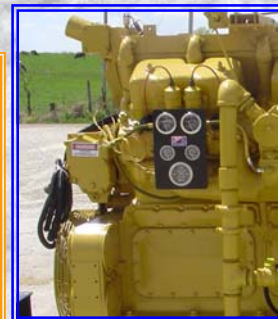


# Current Scene

## Sample of Installations

### KW

400 **Bio-Gas** 2 Caterpillar G399 Dairy Complex Indiana  
 300 **Bio-Gas** 1 Caterpillar G398 Dairy Complex Washington  
 300 **Bio-Gas** 1 Caterpillar G3412 Dairy Complex California  
 200 **Bio-Gas** 2 Caterpillar G3406 Ag & Municipal Collection Oregon  
 200 **Bio-Gas** 1 Caterpillar G3406 Dairy Complex California  
 200 **Bio-Gas** 1 Caterpillar G379 Dairy Complex Wisconsin  
 200 **Bio-Gas** 1 Caterpillar G379 Dairy Complex Wisconsin  
 200 **Bio-Gas** 1 Caterpillar G3406 Dairy Complex California  
 200 **Bio-Gas** 1 Caterpillar G3406 Swine Operation Wyoming  
 150 **Bio-Gas** 2 Caterpillar G342 Dairy Complex California  
 150 **Bio-Gas** 1 Caterpillar Dairy Complex Pennsylvania  
 140 **Bio-Gas** 1 Waukesha 1905 Dairy Complex New York  
 130 **Bio-Gas** 2 Caterpillar Dairy Complex Illinois  
 130 **Bio-Gas** 2 Caterpillar G3406 Dairy Complex Minnesota  
 130 **Bio-Gas** 1 Caterpillar Dairy Complex Wisconsin  
 120 **Bio-Gas** 1 Caterpillar G342 Swine Operation Pennsylvania  
 080 **Bio-Gas** 1 Caterpillar Swine Operation Colorado  
 080 **Bio-Gas** 1 Caterpillar Swine Operation Iowa  
 080 **Bio-Gas** 1 Caterpillar Swine Operation Wyoming  
 050 **Bio-Gas** 1 Caterpillar G3304 Poultry Farm Pennsylvania  
 050 **Bio-Gas** 1 Caterpillar Dairy Complex Pennsylvania



# Disappointments



- Early Valve Failure on new engines



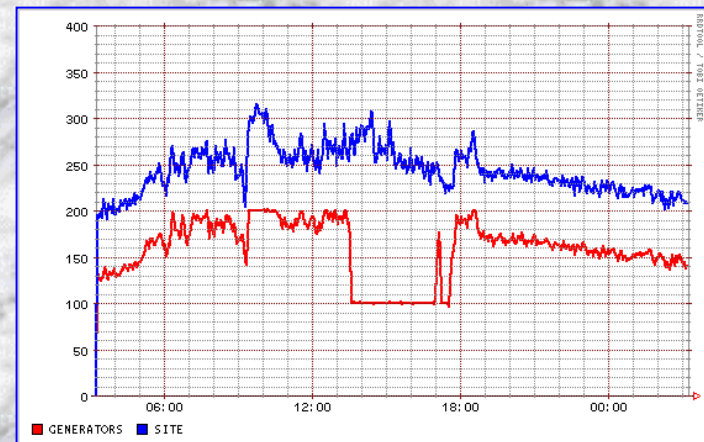
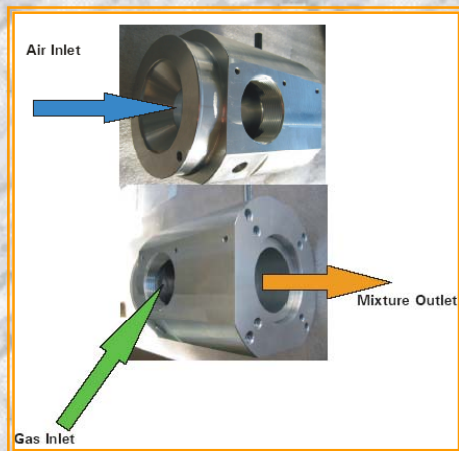
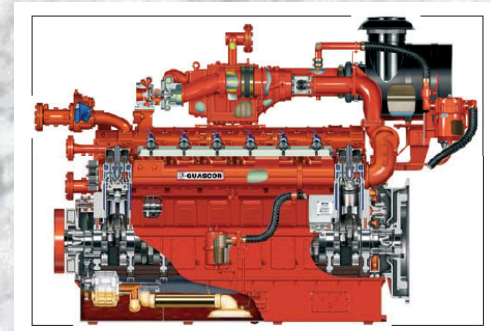
- Wrong bearing materials in replacement parts

# Improvements

- Air/Fuel Ratio controls
- Materials Selection
- Oil Treatment
- Remote Monitoring of Systems
- Energy savings with VFD drives

# Current Developments

- High efficiency Engines
- Data logging/power plant management
- Refinement for engine systems



# Bio Co-Generation Site Specialties

- Generate electricity, 180 Degree water, 15 PSI steam and 150 PSI steam simultaneously.
- Drying whey and manure with waste heat
- Gas "time-of-day" optimization, gas storage options

# Summary

- Focus points: Efficiency, Fuel quality, Emissions and Data acquisition.
- Support post start-up is imperative.
- Integrity in projections and promises.